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(54) **SYSTEM AND METHOD OF SMART ENERGY STORAGE IN A UPS**

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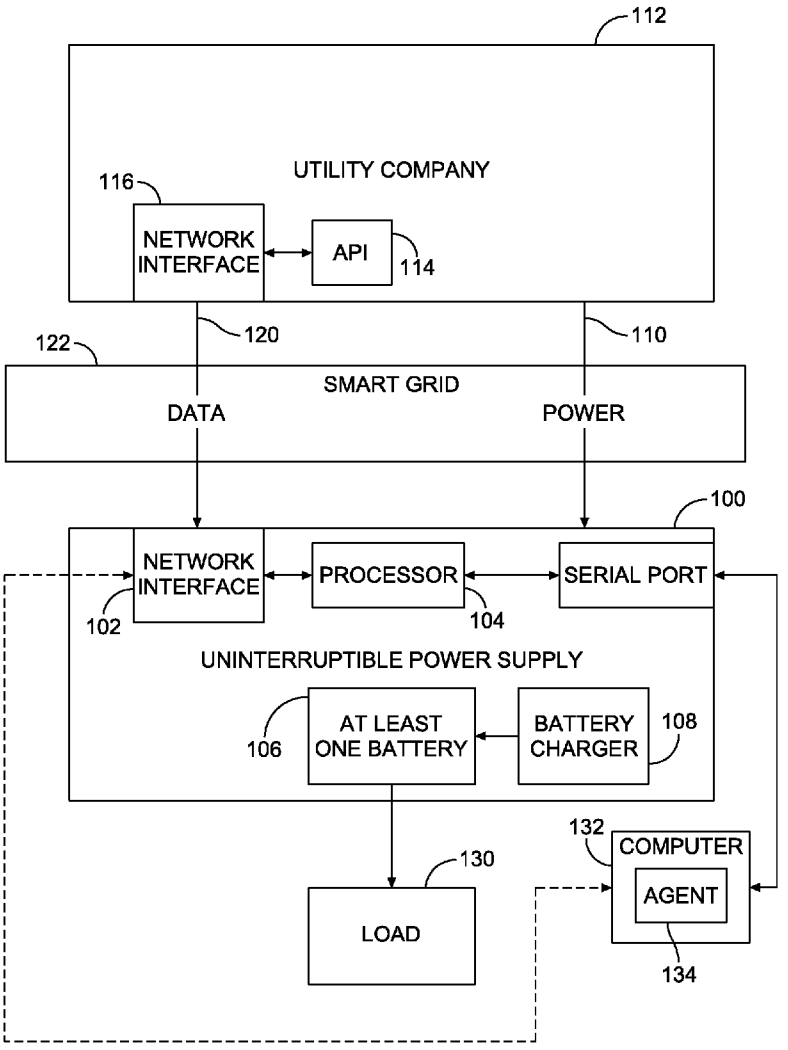
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(57) **ABSTRACT**

A method for controlling an uninterruptible power supply (UPS) having a battery includes powering a load coupled to the UPS using utility power, determining whether an energy cost associated with the utility power exceeds a threshold cost, determining whether a charge level of the battery exceeds a threshold charge level, and powering the load from the battery in response to determining that the energy cost exceeds the threshold cost and that the charge level of the battery exceeds the threshold charge level.



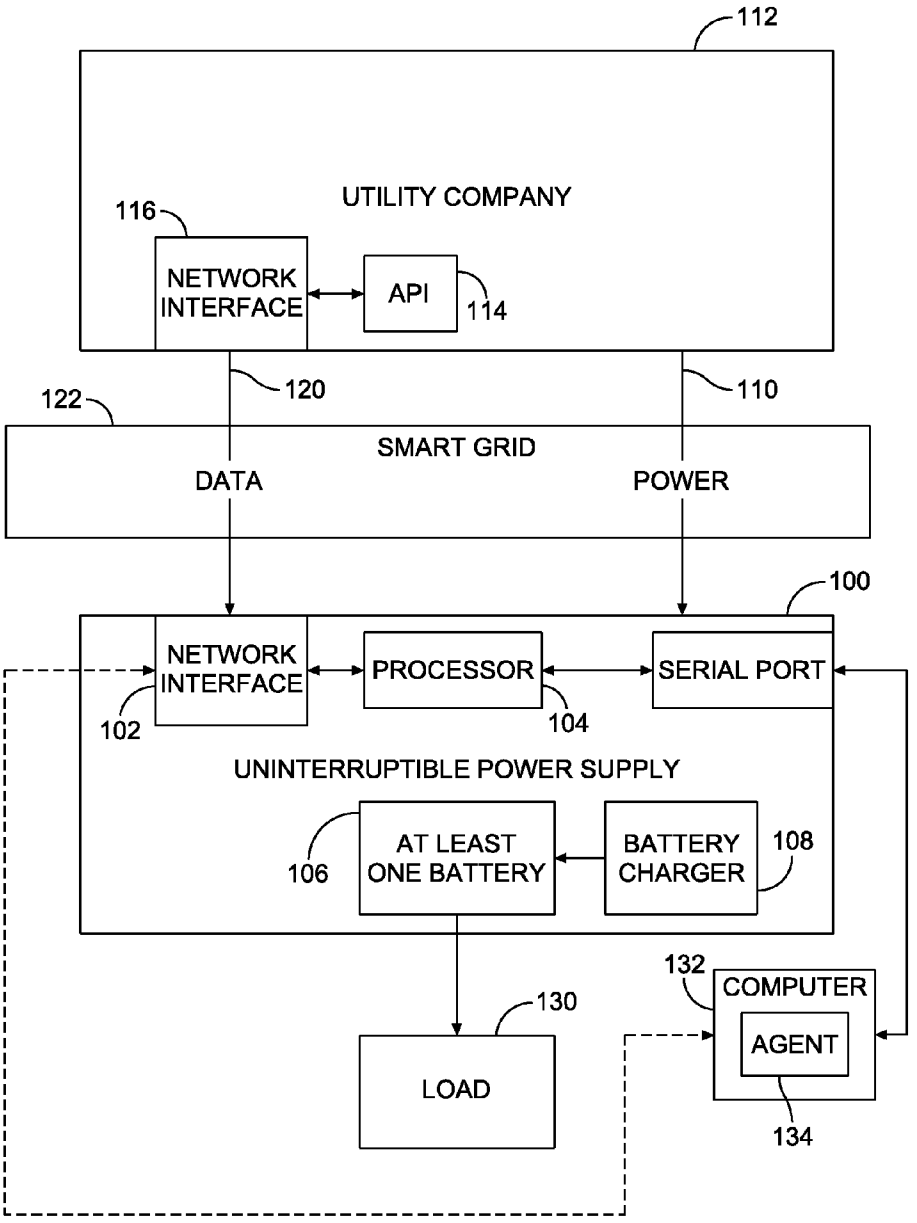

112
UTILITY COMPANY
116
NETWORK INTERFACE
API
114
120
110
122
SMART GRID
DATA
POWER
100
NETWORK INTERFACE
PROCESSOR
SERIAL PORT
102
104
UNINTERRUPTIBLE POWER SUPPLY
106
AT LEAST ONE BATTERY
BATTERY CHARGER
108
132
COMPUTER
AGENT
130
LOAD
134

FIG. 1

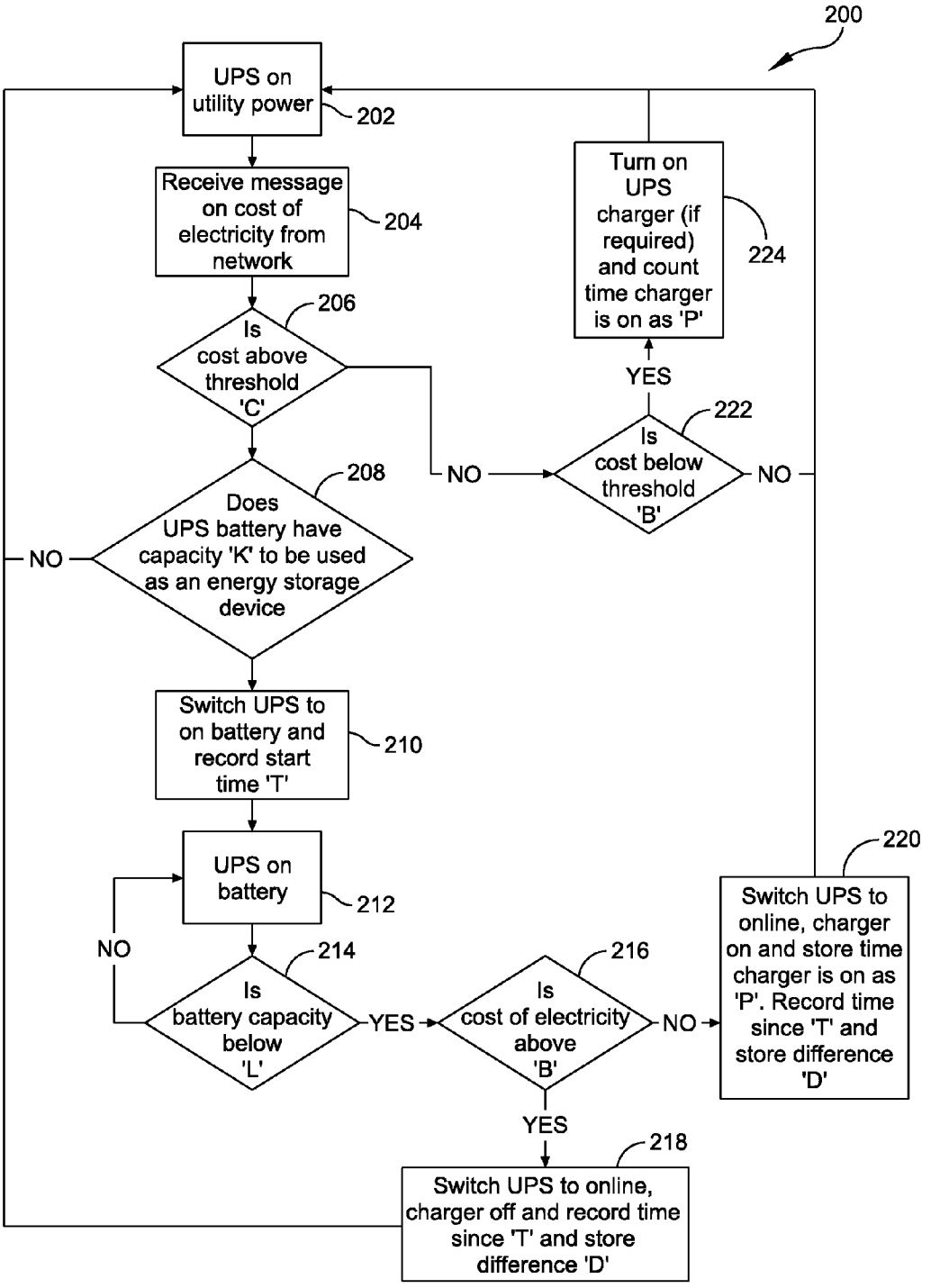

200
UPS on utility power
202
Receive message on cost of electricity from network
204
Is cost above threshold 'C'
206
NO
Does UPS battery have capacity 'K' to be used as an energy storage device
208
NO
Switch UPS to on battery and record start time 'T'
210
UPS on battery
212
NO
Is battery capacity below 'L'
214
YES
Is cost of electricity above 'B'
216
NO
YES
Switch UPS to online, charger off and record time since 'T' and store difference 'D'
218
Switch UPS to online, charger on and store time charger is on as 'P'. Record time since 'T' and store difference 'D'
220
Is cost below threshold 'B'
222
NO
YES
Turn on UPS charger (if required) and count time charger is on as 'P'
224

FIG. 2

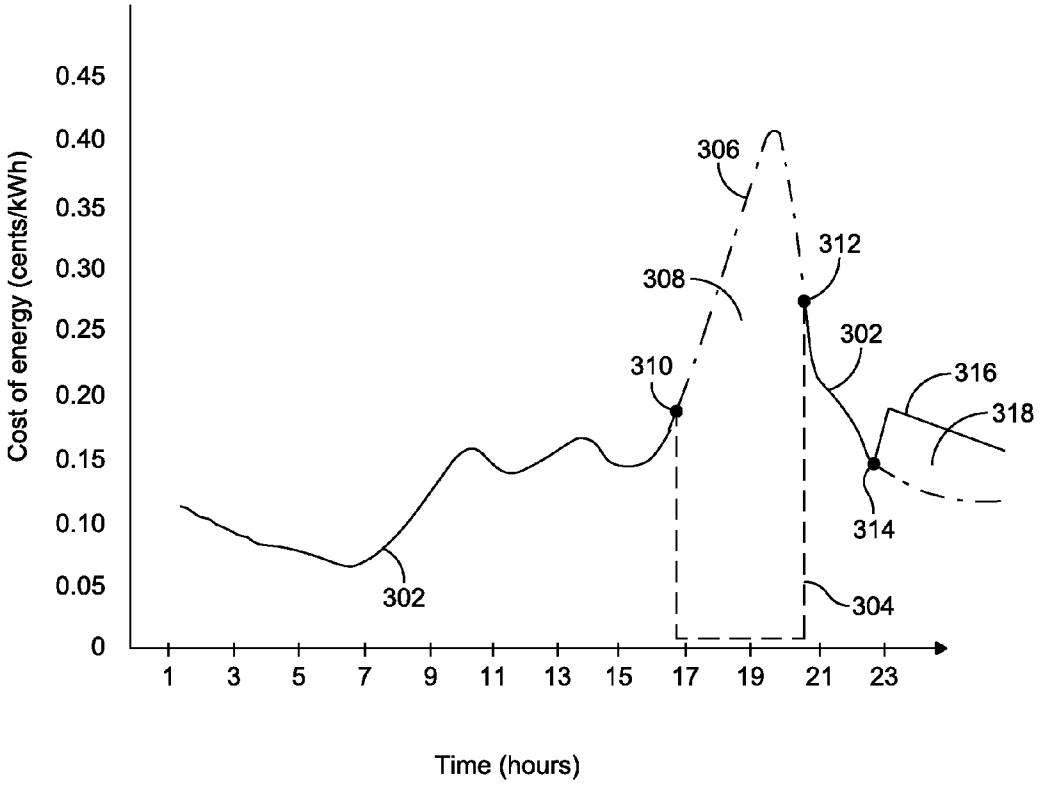

Cost of energy (cents/kWh)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
1
3
5
7
9
11
13
15
17
19
21
23
Time (hours)
306
312
308
302
310
316
318
314
302
304

FIG. 3

SYSTEM AND METHOD OF SMART ENERGY STORAGE IN A UPS

BACKGROUND OF THE INVENTION

[0001] 1. Field of Invention

[0002] Embodiments of the invention relate generally to power management, and more particularly, to systems and methods of smart energy storage in an uninterruptible power supply.

[0003] 2. Discussion of Related Art

[0004] An uninterruptible power supply (UPS) is typically used to provide backup power to an electrical device, or load, while the primary power source, or mains, is unavailable. A conventional online UPS rectifies input power provided by an electric utility using a power factor correction circuit (PFC) to provide a DC voltage to a DC bus. The rectified DC voltage is typically used to charge a battery while mains power is available, as well as to provide power to the DC bus. In the absence of mains power, the battery provides power to the DC bus. From the DC bus, an inverter generates an AC output voltage to the load. Since the DC bus is always powered either by mains or the battery, the output power of the UPS is uninterrupted if the mains fails and the battery is sufficiently charged.

[0005] Typically, a UPS only acts as a source of backup power. While uninterruptible power supplies are typically used to provide a continuous source of power at a local level (e.g., at a data center or in an office or home), such devices primarily depend on utility power due to the limited capacity of the batteries or other energy storage devices used in conjunction with the UPS. Historically, electric utility service has been demand-driven and inefficient, but increasingly technology is being employed to improve the availability, reliability and efficiency of the electric grid. Commonly, these improved electric grids are called "smart grids."

[0006] A "smart grid," as described by the Institute of Electrical and Electronics Engineers (IEEE) of New York, N.Y., includes "a next-generation electrical power system that is typified by the increased use of communications and information technology in the generation, delivery and consumption of electrical energy." As of 2011, a smart grid is considered an overarching and evolving concept that is not limited to any particular technological features, and may also include standards, goals, objectives, and procedures that collectively support the development, implementation, and efficient delivery of reliable, affordable, and sustainable electricity services. Accordingly, no standard definition of smart grid presently exists; rather, the term refers broadly to various interrelated power generation, distribution, and consumption concepts. Some existing electrical power systems presently incorporate one or more elements that may be characterized as forming portions of a smart grid system rather than the whole.

[0007] Among other goals, one objective of a smart grid is to intelligently match power generation with power consumption, rather than treating power consumers as being strictly passive. Historically, electric utilities have relied on total load averages, which are relatively stable and can be computed ahead of time, to anticipate power demands based on reasonable expectations of consumer requirements. The total load average is used to determine a baseload or minimum amount of power that a utility needs to make available without risking an interruption of service.

[0008] However, the total load connected to a power grid can vary significantly over time; for example, commercial power usage is typically higher during daytime than at night, residential power usage is highest during the early morning and evening hours, and loads also increase during periods where heating or cooling demands are greatest. Therefore, by using a total load average, the baseload (and any additional power generation kept in contingency) may be higher than necessary to support loads that fluctuate in real-time. Accordingly, highly reliable power delivery is achieved at the expense of wasted power that is generated in excess of demand. Furthermore, there may be times when the load increases substantially above the baseload capacity of the power utility with little or no warning, which introduces additional reliability and efficiency costs. Electric utility rates rise in proportion to demand, as additional power is generated.

SUMMARY OF THE INVENTION

[0009] According to one embodiment, a method for controlling an uninterruptible power supply (UPS) having a battery includes powering a load coupled to the UPS using utility power, determining whether an energy cost associated with the utility power exceeds a threshold cost, determining whether a charge level of the battery exceeds a threshold charge level, and powering the load from the battery in response to determining that the energy cost exceeds the threshold cost and that the charge level of the battery exceeds the threshold charge level.

[0010] In one embodiment, the method may include receiving, by the UPS, an electric utility rate schedule through a communication network, and determining the threshold cost based on the electric utility rate schedule. In another embodiment, the method may include determining whether the charge level of the battery is below a reserve charge level, and powering the load from utility power in response thereto. In yet another embodiment, the reserve charge level may correspond to a predetermined minimum amount of desired time the load can be powered by the battery.

[0011] In another embodiment, the energy cost of the utility power may be a first energy cost of the utility power, and the threshold cost may be a first threshold cost. The method may include determining whether a second energy cost of the utility power is less than a second threshold cost based on the electric utility rate schedule, and charging the battery using utility power in response thereto. In yet another embodiment, the method may include calculating a cost savings based on an amount of time the load is powered from the battery and the first energy cost.

[0012] In yet another embodiment, the cost savings may be a first cost savings and the amount of time may be a first amount of time. The method may include calculating a second cost savings based on a second amount of time the battery is charged using utility power and the first energy cost.

[0013] According to one embodiment, an uninterruptible power supply includes an input configured to receive utility power, at least one battery, an output configured to provide power to a load, and a processor operatively coupled to the input, the battery (or multiple batteries) and the output. The processor is configured to power the load from the input, determine whether an energy cost associated with the utility power exceeds a threshold cost, determine whether a charge level of the battery exceeds a threshold charge level, and power the load from the battery in response to determining that the energy cost exceeds the threshold cost and that the charge level of the battery exceeds the threshold charge level.

[0014] In one embodiment, the processor may be operatively coupled to a communication network. The processor may be further configured to receive an electric utility rate schedule through the communication network and determine the threshold cost based on the electric utility rate schedule. In another embodiment, the processor may be further configured to determine whether the charge level of the battery is below a reserve charge level, and to power the load from utility power in response thereto. In one embodiment, the reserve charge level may correspond to a predetermined minimum amount of desired time the load can be powered by the battery.

[0015] In another embodiment, the energy cost of the utility power may be a first energy cost of the utility power and the threshold cost may be a first threshold cost. The processor may be further configured to determine whether a second energy cost of the utility power is less than a second threshold cost based on the electric utility rate schedule and to charge the battery using utility power in response thereto. In yet another embodiment, the processor may be further configured to calculate a cost savings based on an amount of time the load is powered from the battery and the first energy cost.

[0016] In another embodiment, the cost savings may be a first cost savings and the amount of time may be a first amount of time. The processor may be further configured to calculate a second cost savings based on a second amount of time the battery is charged using utility power and the first energy cost.

[0017] In one embodiment, the uninterruptible power supply may include a user interface operatively coupled to the processor. The user interface may be configured to display a representation of at least one of the first cost savings and the second cost savings.

[0018] According to one embodiment, an uninterruptible power supply includes an input configured to receive utility power, at least one battery, an output configured to provide power to a load, and means for automatically powering the load from the battery (or multiple batteries) during periods of high energy rates while a charge level of the battery exceeds a threshold charge level, and powering the load from the input during other periods.

[0019] In one embodiment, the uninterruptible power supply may include a network interface operatively coupled to the means. The means may be configured to receive an electric utility rate schedule using the network interface. In another embodiment, the uninterruptible power supply may be configured to automatically power the load from the battery during periods of high energy rates and power the load from utility power during other periods based on the electric utility rate schedule. In yet another embodiment, the uninterruptible power supply may be configured to automatically charge the battery during periods of low energy rates based on the electric utility rate schedule. In yet another embodiment, the means may be further configured to calculate a cost savings realized from powering the load from the battery during periods of high energy rates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The accompanying drawings are not intended to be drawn to scale. In the drawings, each identical or nearly identical component that is illustrated in various figures is represented by a like numeral. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

[0021] FIG. **1** is a block diagram of one example of an uninterruptible power supply in accordance with one embodiment of the present invention;

[0022] FIG. **2** is a flow diagram of one example of a process for controlling a UPS in accordance with one embodiment of the present invention; and

[0023] FIG. **3** is one example of a user interface in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] Embodiments of this invention are not limited in their application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. Embodiments of the invention are capable of other embodiments and of being practiced or of being carried out in various ways. Also, the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having," "containing," "involving," and variations thereof herein, is meant to encompass the items listed thereafter and equivalents thereof as well as additional items.

[0025] Various embodiments relate to power conversion in a UPS; however, embodiments of the invention are not limited for use in uninterruptible power supplies and may be used with other power supplies or other power systems generally. Further, while at least some examples below describe uses with respect to online UPS's, some embodiments can be used with other types of UPS's.

[0026] As discussed above, because the total load connected to the power grid can vary significantly, including UPS loads, there may be times during which the electric utility charges higher rates for energy delivered during periods of peak demand. Although one way to reduce energy costs is to reduce the load while energy rates are high, it is not always convenient to do so, especially for critical loads that cannot be shut down at certain times, or at all. Instead, according to some embodiments, energy expenses incurred by a power consumer can be reduced by shifting loads away from the electric utility to a secondary source of power, such as the battery of a UPS, during high rate periods.

[0027] Some organizations, such as the European Union-sponsored Smarthouse/SmartGrid project, are working on augmenting existing one-way power-only feeds into homes and buildings by providing open standards ICT interfaces on existing IP-based networks, which also serve these same consumers. Such ICT interfaces can be implemented using an application programming interface (API), which can be used to inform consumers when electricity is available, scarce, cheap or expensive. The API may also, for example, be implemented as a two-way communication channel for providing utility companies with the ability to retrieve usage data from consumers in real-time. In one embodiment, the UPS is configured to communicate with the utility company and/or smart grid using the API to send and receive utility rate and usage information. Among other uses, this information may enable the utility companies to deliver enough power to satisfy demand and help balance electricity generation with actual usage to reduce waste. The information may also be used by the consumer to adjust usage patterns to take advantage of lower energy rates during certain time periods. Such uses can substantially increase energy efficiency throughout the grid as well as reducing costs.

[0028] Although conventional uninterruptible power supplies are primarily designed to provide backup power (e.g., from a battery) when the utility power is poor or unavailable, a UPS, according to one embodiment, can be configured to act as an active source of power for a load using the battery instead of utility power during high energy rate periods, so long as the battery has sufficient capacity to power the load. In one embodiment, the UPS can be configured to maintain a reserve capacity in the backup power source as a contingency for power outages, since the backup power source has a limited capacity. In another embodiment, a UPS can be configured to charge the backup power source (e.g., a battery) primarily during periods when energy is relatively inexpensive. By operating the UPS in the one or more of the manners described above, the UPS can be used not only as a source of backup power, but also as a limited source of less expensive power by enabling intelligent use of utility power to take advantage of variable energy rates.

[0029] FIG. **1** is a block diagram of an uninterruptible power supply (UPS) **100** according to one embodiment. The UPS **100** receives AC utility power **110** from a utility company **112**, for example, over a conventional power grid. The utility company **112**, which may be part of, or connected to, a smart grid system **122**, provides an application programming interface (API) **114** that enables the utility company **112** to make information available to consumers about the cost of the energy and, potentially, imminent energy supply problems (e.g., anticipated brownouts, blackouts, or other operational irregularities). The information may be provided using a Service Oriented Architecture (SOA) (e.g., RESTful), as is commonly used for Internet-based services, or another type of API. The information can be transmitted as data **120** through a network interface **116** and a communication network, which may be part of a smart grid **122**, to the UPS, which includes a network interface **102** of its own (e.g., an intelligent network management card or a software agent **134** that resides on a computer **132** connected to the UPS **100**) for communicating on the communication network. The data can be consumed by the UPS **100**, for example, using an integrated processor **104** operatively connected to the communication network. The UPS **100** includes at least one energy storage device, such as a battery **106** or multiple batteries, for storing power, and a battery charger **108** for charging the battery **106**. An electrical load **130** may be connected to the UPS **100**.

[0030] For example, the data **120** may contain information generated by the utility company **112** regarding energy availability and cost. One form of the data **120** can include an electric utility rate schedule, which describes the cost of energy for a particular customer or class of customers on the basis of usage, time of day, and/or other related factors. The UPS **100** may poll the smart grid **122** on a periodic basis for this information, or, alternatively, the utility company **112** or other entity in the smart grid **122** may actively push the information to the UPS **100**, depending on how the smart grid **122** is configured. In one embodiment, the processor **104** can be configured to respond to the information by switching the operating mode of the UPS **100** to act as an energy storage device during times of expensive energy or when energy is predicted to become unavailable. When the battery **106** becomes discharged below a certain threshold, the processor **104** can cause the UPS **100** to switch back to AC utility power **110** to prevent the battery from becoming depleted and preserve the battery charge for future power interruptions.

[0031] In another embodiment, some of the functions of the processor **104** can be implemented in a computer **132** running an agent component **134**, a network management card having a processor and memory, or a distributed processing system. The computer **132** is connected to the processor **104** of the UPS **100** via a serial port **136** or other data interface, such as the network interface **102**, an Ethernet port (not shown) or network management card (NMC). The agent **134** can be configured to process the data **120** and/or control some of the operation of the UPS **100** (e.g., switching between utility power and battery modes). In another embodiment, the UPS **100** and/or the computer **132** can be configured to generate reports of energy usage and cost saved due to the load shifting capability of the UPS **100**. The reports may be presented to a user, for example, through a graphical user interface or other message service, such as electronic mail or text message.

[0032] In one embodiment, the battery charger **108** can be activated by the processor **104** based on the cost of electricity, as determined from the information received from the utility company **112**. For example, the UPS **100** may charge the battery **106** only when energy is relatively cheap, unless charging is needed at other times to replenish the charge in the battery **106**. Another example of how the data **120** may be used by the UPS **100** is described below with respect to FIG. **2**.

[0033] FIG. **2** is a flow diagram of a process **200** for operating a UPS, according to one embodiment. Table 1 lists the legend for various terms shown in FIG. **2**. In one embodiment, one or more of the terms in Table 1 below can be configured by the user.

TABLE 1

Defined terms for flow chart of FIG. 2.

C	Cost of electricity above which the UPS may operate as an energy storage device
B	Cost of electricity below which the UPS may operate the battery charger
T	Start time that the UPS may operate as the energy storage device
D	Total time that the UPS has operated as the energy storage device
K	Battery capacity above which the UPS may operate as an energy storage device (e.g., 75-99%)
L	Battery capacity below which the UPS may switch online to preserve reserve battery capacity (e.g., 25-70%)
P	Time that the battery charger is on

[0034] At block **202**, the UPS powers a load using utility power. At block **204**, the UPS receives a message regarding the cost of electricity on the power grid. When the utility or smart grid reports that energy rates are high (e.g., above threshold C, block **206**), the UPS switches the load to the battery and records the time-on-battery and the cost that the equivalent amount of energy would have cost if sourced from the utility instead of the battery (block **210**). The cost can be used to calculate the amount of money saved by powering the load from the battery instead of from the power grid. The UPS may switch the load to the battery if there is sufficient reserve capacity in the battery (e.g., above capacity K, block **208**); otherwise, the UPS continues to power the load using utility power (block **202**) so as not to compromise the primary function of the UPS, which is to ensure uninterrupted power to the load. At block **212**, the UPS powers the load using the battery.

[0035] If, as above, the utility or smart grid reports that energy rates are low (e.g., below threshold C, block **206**) and the energy rates are below threshold B (block **222**), the UPS

charges the battery, if necessary, and records the charging time (block **224**). The cost and/or cost savings of charging the battery at the prevailing energy rates can thus be calculated and presented to the consumer.

[0036] At block **214**, when the battery in the UPS becomes discharged below level L, the UPS switches the load from the battery to the utility, but keeps the battery charger turned off (block **218**) until the cost of energy as reported by the utility or smart grid is low (e.g., below level B, block **216**) at which time the battery charger may be turned on, if necessary. The time that the battery is being charged is calculated (block **220**), and the cost of energy that would have been used to charge the battery, at the high rate, during that time is also calculated so that the savings resulting from charging the battery at the lower rate can be calculated and presented to the consumer.

[0037] The cost of energy saved using one or more of the above techniques, according to one embodiment, can be calculated as follows:

$$E=\Sigma(D_nY_n)-\Sigma(P_nY_n),$$

where Y_n is the average cost of energy at time n over the total period of time. In one embodiment, a user interface is provided to the user to report the operating mode of the UPS and to display the energy cost savings. FIG. **3** shows one example of a user interface including a graph of energy cost and actual cost plotted over the course of one day (not drawn to scale). It will be understood that the data shown in the graph of FIG. **3** is merely exemplary, and that the actual energy cost is variable and dependent on many factors, including demand, fuel costs and market forces.

[0038] In FIG. **3**, line **302** shows points where the actual cost of energy as reported by the utility company is the same as the actual cost of energy incurred by the user; that is, the user is using utility power during those periods of time and therefore incurring cost at the prevailing utility rates. At point **310**, the actual cost of energy **306** rises sharply, at which point, in this example, the UPS switches operating modes to power the load from the battery instead of from utility power, thus causing the actual cost of energy to become nil. As discussed above, the cost of the power used to charge the battery is low because the battery is charged during periods when the utility rates are relatively low. Line **304** reflects the fact that energy costs drop to nil when the UPS is powering the load from the battery rather than from utility power. Line **306** shows the actual cost of energy during the period of time while the UPS is running on battery. At point **312**, before the charge level of the battery is depleted, the UPS switches from battery to utility power. The point **312** can occur at different points in time depending on the load, the capacity and charge level of the battery, and the desired reserve capacity (e.g., an amount of charge remaining in the battery to power the load for a certain period of time after utility power is lost). For example, if a large reserve capacity is desired, the amount of time the UPS can power the load from the battery may be less than if a small reserve capacity is desired. The user interface of FIG. **3** assumes a constant load and that the UPS did not switch the load to the battery for any reason other than for energy savings. The area between lines **304** and **306** (indicated at **308**) represents the cost savings realized as a result of drawing power from the battery rather than from utility power at the higher rate.

[0039] FIG. **3** also shows that, at point **314**, when the actual cost of energy **302** is relatively low, the UPS may charge the battery using utility power to take advantage of the low cost. The actual cost **316** incurred by the user during this period of time is higher than the actual cost **302** reported by the utility because power is being used to simultaneously charge the battery and power the load. The area between lines **306** and **316** (indicated at **318**) represents the additional cost incurred (above the cost resulting from powering the load with utility power) as a result of charging the battery during this period of time. Thus, the UPS can operate as an energy storage device by storing utility power when the rates are low for later use in powering the load (in lieu of utility power) when the rates are high.

[0040] In one embodiment, the UPS can be configured to provide one or more of the following features:

[0041] Provide recommended actions to the user. For example, the UPS could be configured to recommend energy tariffs based on the environment of the user and the nature of the load supported by the UPS. In another example, the UPS could recommend installing additional batteries to provide additional power savings.

[0042] Allow the user to configure the threshold rates (e.g., rates that trigger switching the UPS to battery power, or rates that trigger the UPS to charge the battery, if necessary). The threshold rates may, for example, be default values or may be derived from information provided by the utility company and/or smart grid.

[0043] Provide automated switching operations. For example, as discussed above, the UPS may continue to act as a source of backup power while also automatically acting as a source of power during periods of high electric rates. In another example, the UPS may monitor the reserve capacity of the battery or batteries and automatically switch from battery power to utility power when necessary to avoid depleting the battery, which could compromise the backup function of the UPS.

[0044] Report generation. For example, the UPS, or a computer using data provided by the UPS, may generate reports, in a variety of formats, for a user on the cost of energy saved by using battery power instead of utility power during peak rate periods, and by charging the battery during off-peak rate periods, taking into account the time the load is being powered from the battery and/or the time the battery is being charged.

[0045] Any of the preceding embodiments can be implemented within a UPS, for example, a UPS having a DC battery as a backup power source. The UPS may be configured to provide backup power for any number of power consuming devices, such as computers, servers, network routers, air conditioning units, lighting, security systems, or other devices and systems requiring uninterrupted power. The UPS may contain, or be coupled to, a controller or control unit to control the operation of the UPS. For example, the controller may provide pulse width modulated (PWM) signals to each of the switching devices within the circuit for controlling the power conversion functions. In another example, the controller may provide control signals for the relays. In general, the controller controls the operation of the UPS such that it charges the battery from the AC power source when power is available from the AC power source, and inverts DC power from the battery when the AC power source is unavailable or during brown-out conditions. The controller can include hardware, software, firmware, a processor, a memory, an

input/output interface, a data bus, and/or other elements in any combination that may be used to perform the respective functions of the controller.

[0046] In the embodiments described above, a battery is used as a backup power source. In other embodiments, other AC or DC backup sources and devices may be used including fuel cells, photovoltaics, DC micro turbines, capacitors, an alternative AC power source, any other suitable power sources, or any combination thereof. In embodiments of the invention that utilize a battery as a backup power source, the battery may be comprised of multiple batteries of cells coupled in parallel or in series internal or external to a UPS.

[0047] Having thus described several aspects of at least one embodiment of this invention, it is to be appreciated various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure, and are intended to be within the scope of the invention. For example, the battery in the UPS may be a lead acid battery, or a lithium ion battery. Lithium ion batteries have the advantage of being able to store more energy for their size than lead acid batteries and do not suffer from the memory problems of lead acid batteries caused by repeated charge/discharge cycles. In another example, some embodiments can be implemented in a UPS having an intelligent network management card that allows users to monitor, configure and control various functions of the UPS over a communication network. Accordingly, the foregoing description and drawings are by way of example only.

What is claimed is:

1. A method for controlling an uninterruptible power supply (UPS) having a battery, the method comprising acts of:
- powering a load coupled to the UPS using utility power;
- determining whether an energy cost associated with the utility power exceeds a threshold cost;
- determining whether a charge level of the battery exceeds a threshold charge level; and
- powering the load from the battery in response to determining that the energy cost exceeds the threshold cost and that the charge level of the battery exceeds the threshold charge level.

2. The method of claim **1**, further comprising receiving, by the UPS, an electric utility rate schedule through a communication network and determining the threshold cost based on the electric utility rate schedule.

3. The method of claim **2**, further comprising determining whether the charge level of the battery is below a reserve charge level, and powering the load from utility power in response thereto.

4. The method of claim **3**, wherein the reserve charge level corresponds to a predetermined minimum amount of desired time the load can be powered by the battery.

5. The method of claim **3**, wherein the energy cost of the utility power is a first energy cost of the utility power, wherein the threshold cost is a first threshold cost, and wherein the method further comprises determining whether a second energy cost of the utility power is less than a second threshold cost based on the electric utility rate schedule and charging the battery using utility power in response thereto.

6. The method of claim **5**, further comprising calculating a cost savings based on an amount of time the load is powered from the battery and the first energy cost.

7. The method of claim **6**, wherein the cost savings is a first cost savings, wherein the amount of time is a first amount of time, and wherein the method further comprises calculating a second cost savings based on a second amount of time the battery is charged using utility power and the first energy cost.

8. An uninterruptible power supply, comprising:
- an input configured to receive utility power;
- at least one battery;
- an output configured to provide power to a load; and
- a processor operatively coupled to the input, the at least one battery and the output, the processor configured to:
  - power the load from the input;
  - determine whether an energy cost associated with the utility power exceeds a threshold cost;
  - determine whether a charge level of the at least one battery exceeds a threshold charge level; and
  - power the load from the at least one battery in response to determining that the energy cost exceeds the threshold cost and that the charge level of the battery exceeds the threshold charge level.

9. The uninterruptible power supply of claim **8**, wherein the processor is operatively coupled to a communication network, and wherein the processor is further configured to receive an electric utility rate schedule through the communication network and determine the threshold cost based on the electric utility rate schedule.

10. The uninterruptible power supply of claim **9**, wherein the processor is further configured to determine whether the charge level of the at least one battery is below a reserve charge level, and to power the load from utility power in response thereto.

11. The uninterruptible power supply of claim **10**, wherein the reserve charge level corresponds to a predetermined minimum amount of desired time the load can be powered by the at least one battery.

12. The uninterruptible power supply of claim **10**, wherein the energy cost of the utility power is a first energy cost of the utility power, wherein the threshold cost is a first threshold cost, and wherein the processor is further configured to determine whether a second energy cost of the utility power is less than a second threshold cost based on the electric utility rate schedule and to charge the at least one battery using utility power in response thereto.

13. The uninterruptible power supply of claim **12**, wherein the processor is further configured to calculate a cost savings based on an amount of time the load is powered from the at least one battery and the first energy cost.

14. The uninterruptible power supply of claim **13**, wherein the cost savings is a first cost savings, wherein the amount of time is a first amount of time, and wherein the processor is further configured to calculate a second cost savings based on a second amount of time the at least one battery is charged using utility power and the first energy cost.

15. The uninterruptible power supply of claim **14**, further comprising a user interface operatively coupled to the processor, wherein the user interface is configured to display a representation of at least one of the first cost savings and the second cost savings.

16. An uninterruptible power supply, comprising:
- an input configured to receive utility power;
- at least one battery;
- an output configured to provide power to a load; and
- means for automatically powering the load from the at least one battery during periods of high energy rates while a

charge level of the at least one battery exceeds a threshold charge level, and powering the load from the input during other periods.

17. The uninterruptible power supply of claim **16**, further comprising a network interface operatively coupled to the means, wherein the means is configured to receive an electric utility rate schedule using the network interface.

18. The uninterruptible power supply of claim **17**, wherein the uninterruptible power supply is configured to automatically power the load from the at least one battery during periods of high energy rates and power the load from utility power during other periods based on the electric utility rate schedule.

19. The uninterruptible power supply of claim **18**, wherein the uninterruptible power supply is configured to automatically charge the at least one battery during periods of low energy rates based on the electric utility rate schedule.

20. The uninterruptible power supply of claim **16**, wherein the means is further configured to calculate a cost savings realized from powering the load from the at least one battery during periods of high energy rates.

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